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Effect of hybrid and conventional maize varieties on biology and morphometric of *Chilo partellus* (Swinhoe) (Lepidoptera: Pyralidae)

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ABSTRACT

Maize stem borer, *Chilo partellus* (Swinhoe) is one of the major pests of maize causing a huge loss to production. The present study was conducted to assess biological life stages, length, and weight of *C. partellus* on conventional maize and hybrid maize in laboratory conditions. The results found that eggs hatched between 4-8 days on conventional maize and 4 to 7 days on hybrid maize. The total larval period ranged results for the total larval duration of the maize stem borer ranged from 20 to 48 days on conventional and 18 to 42 days on hybrid maize. During its larval period the caterpillar moulted five times and had six larval instars. The mean average length of all larval instars ranged from 4.16±0.32 to 29.89±1.06mm on conventional maize, while 3.22±0.23 to 24.44±0.11mm on hybrid maize. The weight of larval instars reared on conventional maize was found greater than reared on hybrid maize. The fully developed larva undergoes pupation in the larval tunnel with total duration of 5 to 8 days on both conventional and hybrid maize. The results for an average mean pupal length of 18.06±0.06 measured on conventional maize and 16.67±0.10 mm on hybrid maize. However, average mean pupal weight varied from 0.418±0.019g maximum on conventional maize and 0.352±0.003g minimum on hybrid maize. The longevity of female adults varied from 6 to 8 days on conventional maize and 4 to 8 on hybrid maize and for male adults it varied from 4 to 8 days on conventional maize and 4 to 6 on hybrid maize. The length of adult females varied from 16.20 mm to 17.77 mm on conventional maize, while 13.77 mm to 14.37 mm on hybrid maize. The weight of adult female reared on conventional maize varied from 0.834g to 0.902g, whereas, 0.704g to 0.832g on hybrid maize.

Keywords: Maize, Stem borer, *Chilo partellus*, hybrid

1. INTRODUCTION

In Pakistan, maize (*Zea mays* L.) is 3rd important cereal after wheat and rice and it is an edible grain. Maize is used as a raw product for manufacturing many industrial products (Afzal *et al.,* 2009). Maize is the most completely domesticated crop among the cereals (Martin *et al.,* 2002). Maize is one of the important cereal crops of the world, cultivated for food, fodder and for raw material in many industries. In Pakistan, maize is the most important cereal after wheat and rice. Maize is a multipurpose crop, providing food and fuel for human, feed for poultry and livestock and have a great nutritional value. Maize is used as raw product for manufacturing many industrial products (Afzal *et al.,* 2009). During 2008-2009, maize was grown on 1052.1 ha in Pakistan with an average production of 3415 kg ha-1 and with a total production of 3593 tons (MINFA, 2009).

Chilo partellus (Swinhoe) (Lepidoptera: Pyralidae) originated in the India-Pakistan region and is an important pest in Asian and African countries and is most destructive one causing heavy yield loss up to the degree of 15 -75% (Kumar, 2002; Arab Jafari and Jalali, 2007). The stem borer, *C. partellus* is a serious pest of cereals; *Sorghum bicolor* (L) and *Z. mays* in various parts of Asia and Africa (Seshu, 1998, Sethuraman and Narayanan, 2010; Songa *et al.,* 2001). (Farid *et al.,* 2007) reported 10-50% damage by maize stem borer in Peshawar valley. Yield losses caused by stem borers in Africa are as high as 80% for maize alone, while in Kenya, 18% yield losses were attributed to *C. partellus* and *C. orichalocociliellus* in maize and as much as 88% in sorghum by *C. partellus*. Maximum stalk damage in maize and up to 80% grain yield loss in sorghum by *C. partellus* were reported in 20 days old crops, whereas, similar infestations induced no significant loss when plants were infested soon (6 days) after emergence (Van Den Berg, 2009).

Biology of *C. partellus* in Indian conditions has been reviewed thoroughly (Harris, 1990). In order to develop pheromonal control strategies for this pest, especially mass-trapping and mating disruption, it is important to have a thorough understanding of the reproductive biology and behavior - particularly the mating and egg-laying capacities of the moths and the factors which influence them. Therefore, for sound management, it is essential to know the weak links in the bio-ecology, life history, and duration of different developmental stages.

The body length measurements have been used to evaluate the biomass of insects in (Rogers *et al.,* 1976; Schoener, 1980; Gowing and Recher, 1984, Dial and Roughgarden, 1995) or, more rarely, to estimate the growth rate of immature when it is not possible or desirable to weigh them directly (Rausher, 1979, Feeny *et al.,* 1985, Costa, 1991; Denno and Benrey, 1997). Literature pertaining to biology and morphometry of *C. partellus* is meager. Hence, the present investigations were taken to give the emphasis on biological and morphometric measurements of *C. partellus* of both hybrid and conventional maize varieties with the following objectives:

Objectives of the study

1. To compare biology (life cycle) of *C. partellus* on hybrid and conventional maize

2. To compare morphometric (length and weight) measurements of *C. partellus* on hybrid and conventional maize.

2. MATERIALS AND METHODS

Insect Material and Rearing Method

Enough different larval instars population of *C. partellus* were collected from Hybrid (P1543) variety by DuPont Pioneer and conventional (Pak-Afgoi) variety of maize by Jullundur Group at Allah Dino Sand Agricultural Farm, District Matiari, Sindh-Pakistan. The collected larvae were reared for F1 generation at Post Graduate Laboratory, Department of Entomology, Faculty of Crop Protection, Sindh Agriculture University Tandojam on fresh maize leaves and stalks as diet. The insect laboratory colony was kept at 27 ± 1°C, 70 ± 5 % R.H. and 14L: 10D photoperiod.

Experimental design =Complete Randomize Design (CRD).
Treatments = Two
Replications = Three

Data Observations

Biology: For this experiment, the F_1 generation of *C.partellus* of both hybrid and conventional maize crop from egg up to the adult was observed. The duration of biological parameters such as egg, larval instars, pupa, and adult longevity assessment was observed.

Morphometric: For this experiment, length in mm by foot scale and weight in gram by weight balance machine of all the *C .partellus* larval stages, pupa and adults were measured and compared from both hybrid and conventional maize crops.

Statistical analysis

The data were subjected to do Student T-Test by using statistical analysis utilizing "GraphPad Crystal adaptation 5.00 for Windows, GraphPad Programming, San Diego California USA, www.graphpad.com".

3. RESULTS

The aggregate life cycle span from egg to grown-up and morphometric characters like length and load of every single larval instar, pupa and grown-up (male, female) of *C. partellus* were considered in the research facility by giving crisp maize plant leaves and stems as their eating routine at prescribed room temperature and relative humidity throughout the study.

Table 1 Effect of hybrid and conventional maize in the span of various life phases of maize stem borer, *Chilo partellus* in research facility conditions

Life stages Duration	Conventional Maize			Hybrid Maize		
	Range		Mean±S.E	Range		Mean±S.E
	Min	Max		Min	Max	
Egg period	4	8	6.00±2.00	4	7	5.50±1.50
Larval instar I	3	7	5.00±2.00	3	7	5.00±2.00
instar II	2	9	5.50±3.50	2	8	5.00±3.00
instar III	4	8	6.00±2.00	4	7	5.50±1.50
instar IV	4	8	6.00±2.00	3	8	5.50±2.50
instar V	3	6	4.50±1.50	2	6	4.00±2.00
instar VI	4	10	7.00±3.00	4	8	6.00±2.00
Pupa	5	8	6.50±1.50	5	8	6.50±1.50
Adult Female Longevity	6	8	7.00±1.00	4	8	6.00±2.00
Adult Male Longevity	4	8	6.00±2.00	4	6	5.00±1.00
Total Life Cycle	34	72	53.00±19.00	31	66	48.50±17.50

Egg

C. partellus eggs were observed under the surface of the leaves into sufficient nearly 10 to 20 eggs mass. They appeared with light brown in color. Eggs hatched after an incubation period were ranged between 4-8 days with an average of 6.00±2.00 days on conventional maize, however, 4-7 days of range with average mean of 5.50±1.50 were observed on hybrid maize, showing no any difference between the two treatments (Table-1). However, due to lack of resources, both length and weight of eggs were not measured.

Larva

The *C. partellus* larva undergoes six larval instars.

First instar larva

1st instar larvae were very much active, small and slender in shape. The results in table-1 showed that the total duration of first instar larvae ranged between 3-7 days on both conventional and hybrid maize with an average mean of 5.00±2.00 days. The length of first instar larvae varied from 3.53mm to 4.60 mm with an average of 4.16 ± 0.32 mm on conventional maize, while 2.80mm-3.60mm with an average mean of 3.22 ± 0.23 mm on hybrid maize (Table-2). The weight in grams for first instar larva also varied significantly between the two treatments. The weight reared on conventional maize varied from 0.003g to 0.0.005g with an average of 0.004 ± 0.000g, while on hybrid maize it was found less as compared to conventional maize with range of 0.001g to 0.002g with an average of 0.002 ± 0.000g (Table-3).

Second instar larva

The results showed in table-1 that the total duration of second instar larvae ranged between 2-9 days on both conventional and hybrid maize with average mean of 5.00±2.00 days. The length of second instar hatchlings differed from 6.67to 7.93 mm with a normal of 7.11 ± 0.55 mm on conventional maize, while 4.80mm to 6.50mm with an average mean of 5.89 ± 0.55 mm on hybrid maize (Table-2). The weight reared on conventional maize varied from 0.011g to 0.0.029g with an average of 0.019 ± 0.005g, while on hybrid maize it was found less as compared to conventional maize with range of 0.006g to 0.008g with an average of 0.007 ± 0.001g (Table-3).

Table 2 Effect of hybrid and conventional maize on length of diverse life phases of maize stem borer, *Chilo partellus* in research laboratory conditions

Life Stage	Conventional Maize				Hybrid Maize			
	Length (mm)			Mean±S.E	Length (mm)			Mean±S.E
	R1	R2	R3		R1	R2	R3	
Larval instar I	3.53	4.33	4.60	4.16±0.32	2.80	3.27	3.60	3.22±0.23
instar II	6.67	7.33	7.93	7.11±0.55	4.80	6.37	6.50	5.89±0.55
instar III	10.67	14.67	12.17	12.50±1.17	7.33	9.67	10.33	9.11±0.91
instar IV	16.83	19.83	17.67	18.11±0.89	15.83	14.00	14.00	14.61±0.61
instar V	24.50	24.83	26.83	25.39±0.73	17.67	19.33	19.50	18.83±0.58
instar VI	28.67	29.00	32.00	29.89±1.06	24.33	24.33	24.67	24.44±0.11
Pupa	18.17	18.00	18.00	18.06±0.06	16.50	16.67	16.83	16.67±0.10
Male	14.77	15.70	14.60	15.02±0.34	12.83	12.50	12.33	12.55±0.15
Female	17.17	16.20	17.77	17.05±0.46	14.17	14.37	13.77	14.10±0.18

Third instar larva

The results showed that the total duration of third instar larvae ranged between 4-8 days on conventional maize with an average overall mean of 6.00±2.00 days while third instar larval duration ranged between 4-7 days on hybrid maize with average overall

mean of 5.50±1.50 days (Table-1). The length of 3rd instar hatchlings differed from 10.67 mm to 14.67 mm with a normal overall mean of 12.50 ± 1.17 mm on conventional maize, while 7.33mm to 10.33mm with an average overall mean of 9.11 ± 0.91 mm on hybrid maize (Table-2). The weight reared on conventional maize varied from 0.069g to 0.100g with an average overall mean of 0.083 ± 0.009g, while on hybrid maize it was found.

Fourth instar larva

The results showed that the total duration of fourth instar larvae ranged between 4-8 days on conventional maize with an average overall mean of 6.00±2.00 days while fourth instar larval duration ranged between 3-8 days on hybrid maize with average overall mean of 5.50±2.50 days (Table-1). The length of fourth instar hatchlings differed from 16.83 mm to 19.83 mm with a normal overall mean of 18.11±0.89 mm on conventional maize, while 14.00 mm to 15.83 mm with an average overall mean of 14.61±0.61mm on hybrid maize (Table-2). The weight reared on conventional maize varied from 0.165 g to 0.205 g with an average overall mean of 0.181±0.012 g, while on hybrid maize it was found less as compared to conventional maize with range of 0.081 g to 0.102 g with an average overall mean of 0.091±0.006 g (Table-3).

Fifth instar larva

The results showed that the total duration of fifth instar larvae ranged between 3-6 days on conventional maize with an average overall mean of 4.50±1.50 days while fifth instar larval duration ranged between 2-6 days on hybrid maize with average overall mean of 4.00±2.00 days (Table-1). The length of fifth instar hatchlings shifted from 24.50 mm to 26.83 mm with a normal in general mean of 25.39±0.73 mm on traditional maize, while 17.67 mm to 19.50 mm with a normal by and large mean of 18.83±0.58 mm on hybrid maize (Table-2). The weight reared on conventional maize varied from 0.371 g to 0.511 g with an average overall mean of 0.449±0.041 g, while on hybrid maize it was found less as compared to conventional maize with range of 0.233 g to 0.311 g with an average overall mean of 0.272±0.023 g (Table-3).

Table 3 Effect of hybrid and conventional maize on the weight of distinctive life phases of maize stem borer, *Chilo partellus* in research laboratory conditions

Life Stage	Conventional Maize				Hybrid Maize			
	Weight (g)			Mean±S.E	Weight (g)			Mean±S.E
	R1	R2	R3		R1	R2	R3	
Larval instar I	0.003	0.004	0.005	0.004±0.000	0.002	0.001	0.002	0.002±0.000
instar II	0.011	0.018	0.029	0.019±0.005	0.008	0.007	0.006	0.007±0.001
instar III	0.069	0.079	0.100	0.083±0.009	0.029	0.053	0.057	0.046±0.009
instar IV	0.165	0.205	0.172	0.181±0.012	0.081	0.091	0.102	0.091±0.006
instar V	0.466	0.511	0.371	0.449±0.041	0.233	0.311	0.271	0.272±0.023
instar VI	0.633	0.618	0.704	0.652±0.027	0.366	0.478	0.504	0.449±0.042
Pupa	0.447	0.424	0.383	0.418±0.019	0.357	0.349	0.349	0.352±0.003
Male	0.855	0.763	0.741	0.786±0.035	0.673	0.609	0.675	0.652±0.021
Female	0.902	0.882	0.834	0.873±0.020	0.832	0.735	0.704	0.757±0.039

Sixth instar larva

The results showed that the total duration of sixth instar larvae ranged between 4-10 days on conventional maize with an average overall mean of 7.00±3.00 days while sixth instar larval duration ranged between 4-8 days on hybrid maize with average overall mean of 6.00±2.00 days (Table-1). Length of fifth instar hatchlings changed from 24.50 mm to 26.83 mm with a normal generally speaking mean of 25.39±0.73 mm on regular maize, while 17.67 mm to 19.50 mm with a normal in general mean of 18.83±0.58 mm (Table-2). The weight reared on conventional maize varied from 0.618 g to 0.704 g with an average overall mean of 0.652±0.027 g,

while on hybrid maize it was found less as compared to conventional maize with range of 0.366 g to 0.504 g with an average overall mean of 0.449±0.042 g (Table-3).

Pupa

Pupation takes place inside the larval tunnel. Pupa was ruddy darker in shading. The male pupa was somewhat tight and littler than that of the female.

The results showed that pupal duration ranged between 5-8 days with an average overall mean of 6.50±1.50 days on both on conventional maize and hybrid maize (Table-1). The length of the pupa changed from 18.00 mm to 18.17 mm with a normal by and large mean of 18.06±0.06 mm on customary maize, while 16.50 mm to 16.83 mm with a normal by and large mean of 16.67±0.10 mm on hybrid maize (Table-2). The weight reared on conventional maize varied from 0.383 g to 0.447 g with an average overall mean of 0.418±0.019 g, while on hybrid maize it was found less as compared to conventional maize with range of 0.349 g to 0.357 g with an average overall mean of 0.352±0.003 g (Table-3).

Adult

The adult moths of *C. partellus* were medium in size and yellowish dark-colored to straw shaded. The forewings were pale straw, while the rear wings had black spots along their outer margins.

Adult Female *C. partellus*

The results showed that adult female longevity took place between 6-8 days on conventional maize with an average overall mean of 7.00±1.00 days while on hybrid maize it ranged between 4-8 days on hybrid maize with average overall mean of 6.00±2.00 days (Table-1). The length of adult females varied from 16.20 mm to 17.77 mm with an average overall mean of 17.05±0.46 mm on conventional maize, while 13.77 mm to 14.37 mm with an average overall mean of 14.10±0.18 mm on hybrid maize (Table-2). The weight of adult female reared on conventional maize varied from 0.834 g to 0.902 g with an average overall mean of 0.873±0.020 g, while on hybrid maize it was found less as compared to conventional maize with range of 0.704 g to 0.832 g with an average overall mean of 0.757±0.039 g (Table-3).

Adult male *C. partellus*

The results showed that adult male longevity took place between 4-8 days on conventional maize with an average overall mean of 6.00±2.00 days while on hybrid maize it ranged between 4-6 days on hybrid maize with average overall mean of 5.00±1.00 days (Table-1). The length of adult males varied from 14.60 mm to 15.70 mm with an average overall mean of 15.02±0.34 mm on conventional maize, while 12.33 mm to 12.83 mm with an average overall mean of 12.55±0.15 mm on hybrid maize (Table-2). The weight of adult male reared on conventional maize varied from 0.741 g to 0.855 g with an average overall mean of 0.786±0.035 g, while on hybrid maize it was found less as compared to conventional maize with range of 0.609 g to 0.675 g with an average overall mean of 0.652±0.021 g (Table-3) Less as compared to conventional maize with a range of 0.029g to 0.057g with an average overall mean of 0.046 ± 0.009g (Table-3).

Total life cycle

The results showed that the total life cycle of *C. partellus* ranged between 34-72 days on conventional maize with an average overall mean of 53.00±19.00 days while total larval duration ranged between 31-66 days on hybrid maize with average overall mean of 48.50±17.50 days (Table-1).

The statistical results were sorted out by two-tailed paired student t-test and showed that means for biological cycles or life stages were significantly different (p=0.0011; t=4.714; df=9) between the two treatments i.e., conventional maize and hybrid maize (Appendix-I). The t-test results for mean lengths of *C. partellus* between both treatments were highly significant as (p=0.0013; t=4.853; df=8) (Appendix-II).

4. DISCUSSION

Maize is a standout amongst the most essential grain edits after wheat and rice in India (Kumar and Alam, 2017). In several tropical and subtropical countries, it is used as a principal staple food. Even though, increasing year by year the efficiency is still significantly low which might be because of a few reasons and one of that is without a doubt the assault of different bug bothers especially the stem borer, *Chilo partellus* (Swinhoe) which makes more prominent misfortunes this harvest (Prakash *et al.,* 2017). Yield losses up to 75 percent are reported from this pest alone (Shahid *et al.,* 2018)**.** Maize stem borer *C. partellus* starts its infestation by ovipositing

on the leaves (Ajala and Saxena, 1994). Siddalingappa *et al*. (2010) studied extensively on biology of this pest and lot of information available on the life cycle of it Saranya and Samiayyan (2017).The present study was evaluated to discuss the duration of biological cycles and morphometric i.e., length and weight of *C. partellus* reared on both conventional maize and hybrid maize in the laboratory conditions. The results observed that *C. partellus* eggs were laid under surface of the leaves in masses nearly 10 to 20 eggs/mass. They appeared with light brown in color. Eggs hatched after an incubation period was ranged between 4-8 days on conventional maize, however, 4-7 days of range were observed on hybrid maize. Similar observations were reported Siddalingappa *et al.* (2010) that the brooding period fluctuates from 3 to 6 days.

The length of larval instars was measured with an average range of 4.16±0.32 mm minimum and it lasted with 29.89±1.06mm maximum on conventional maize, while 3.22 ± 0.23 mm minimum on hybrid maize and 24.44±0.11mm maximum. The same trend was also found for weight on hybrid maize as compared to conventional maize. The first instar larval duration lasted for 3-7 days with a normal of 5.00±2.00 days, as detailed by Panchal and Kachole (2013) that normal term of first instars was 4.80 ± 0.78 days, which is pretty much in simultaneousness with present discoveries. However, results for total larval span of the stem borer fluctuated from 20 to 48 days in the present examination and found comparative with Siddalingappa *et al.* (2010) who detailed the aggregate larval period was 20 to 51 days and Deshpande (1978) and Marulasiddesha (1999). The above reports are pretty much comparable with the present discoveries. The varieties in larval spans might be because of research center conditions like temperature and relative moistness. The results for an average mean pupal length varied from 18.06±0.06 mm maximum and 16.67 ± 0.10 mm minimum on hybrid maize. However, average means pupal weight varied from 0.418±0.019g maximum and 0.352±0.003g minimum on hybrid maize. However, the pupal period lasted for 5 to 8 days on both conventional and hybrid maize. These findings are found in close agreement with Deshpande (1978).

Adults were dirty brown and nocturnal in habit and hide in dried leaves during day times. The emergence of adults usually occurred during evening time. The longevity of the adults was studied by providing cotton dipped in 10 percent nectar arrangement as nourishment. The length of adult females varied from 16.20 mm to 17.77 mm on conventional maize, while 13.77 mm to 14.37 mm on hybrid maize. The weight of adult female reared on conventional maize varied from 0.834g to 0.902g, whereas, 0.704g to 0.832g on hybrid maize. The present study results for longevity of female adults varied between 6-8 days on conventional maize and 4-8 on hybrid maize. The length, weight, and longevity in case of adult males were found less as compared to females. The observations on adult descriptions were in partial agreement with Deshpande (1978).The present study showed that total life cycle of *C. partellus* ranged between 34-72 days on conventional maize and 31-70 days on hybrid maize and these results partially agree with Deshpande (1978) reported life-cycle of insect varied from 34 to 56 days. However, the differences in life cycle varied due to ups and downs of laboratory temperature and relative humidity.

5. CONCLUSION

From the present laboratory studies compare two different traits, it is concluded that maize stem borer, *Chilo partellus* showed better development on conventional maize as compared to hybrid maize. The lengths from larva up to adults were measured more on conventional in comparison to hybrid maize. For weight it was concluded that the larva to adult *C. partellus* did not show any big difference. However, the results further conclude that overall life cycle duration of *C. partellus* lasted larger days on conventional maize as compared to hybrid maize.

Recommendations

From the present concluded results, it may be recommended that:

- Hybrid varieties of maize should be introduced for control of *C. partellus* development in the field.
- Furthermore, studies may be carried out to find out the reasons behind the low development, length, and weight between the two maize traits.

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Conflict of Interest: The authors declare that there are no conflicts of interests.

Appendices

Appendix-I T-test of different life stages of maize stem borer, *Chilo partellus* in laboratory conditions between hybrid and conventional maize

Parameter	
Table Analyzed	Data 1
Column A	Conventional Maize
Vs	Vs
Column B	Hybrid Maize
Paired t test	
P value	0.0011
P value summary	**
Are means signif. different? (P < 0.05)	Yes
One- or two-tailed P value?	Two-tailed
t, df	t=4.714 df=9
Number of pairs	10

Appendix-II T-test of lengths of different life stages of maize stem borer, *Chilo partellus* in laboratory conditions between hybrid and conventional maize

Parameter	
Table Analyzed	Data 1
Column A	Conventional Maize
Vs	Vs
Column B	Hybrid Maize
Paired t test	
P value	0.0013
P value summary	**
Are means signif. different? (P < 0.05)	Yes
One- or two-tailed P value?	Two-tailed
t, df	t=4.853 df=8
Number of pairs	9

Parameter	
Table Analyzed	Data 1
Column A	Conventional Maize
Vs	Vs
Column B	Hybrid Maize
Paired t test	
P value	0.0043
P value summary	**
Are means signif. different? (P < 0.05)	Yes
One- or two-tailed P value?	Two-tailed
t, df	t=3.942 df=8
Number of pairs	9

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